

Emergency power generating unit for trains and train comprising said unit

Description

Technical field

5 The invention relates to an emergency power unit for generating electrical, mechanical or thermal power for a transportation vehicle and more specifically for a train.

The invention also concerns a transportation vehicle and more particularly a train equipped with an emergency generating unit.

Background of the invention

10 Modern trains are equipped with technical systems which require continuous power for operation. Power is supplied by the electrical line along the railway track. Of all the technical systems installed aboard trains, air conditioning systems draw most power. These systems are used on all modern trains, specifically high speed trains. The windows of such trains are  
15 generally sealed and cannot be opened by travelers for safety reasons. On the other hand, specifically high speed trains (especially those intended to travel alternatively on dedicated tracks and on normal railway tracks employed for traditional - i.e. not high speed - railway traffic) are frequently subject to breakage of the pantograph connecting the locomotive to the  
20 electrical power line with consequent power outage, that causes the train to stop and the on-board systems to stop working. The power outage concerning air conditioning systems and the impossibility of opening the windows to ventilate the trains causes extreme discomfort and may even be dangerous for passengers.

25 The power drawn by each air conditioning system aboard modern trains is considerable. Typically, the power required is in the order of 40 kW for each carriage. Since the train may stop for a long time (in the order of 1-2 hours), ensuring sufficient autonomy for air conditioning systems for such a long time is not possible using electrical batteries considering that they draw  
30 so much power. This solution (and others) would be excessively heavy.

Objects and summary of the invention

Object of the invention is to provide an emergency generating unit

which is suitable - in terms of weight, size and output power, as well as autonomy and costs - for use on trains. Additional object of the invention is also the realization of a train equipped with a suitable emergency generating unit.

5           Essentially, according to the invention, an emergency generating unit for a train is characterized in that it comprises a gas turbine. The gas turbine forms a mechanical power generator suitable to output sufficient power to supply train utilities, specifically to supply the energy needed to run the air conditioning system of a single carriage. Preferably, the turbine is fed with  
10 liquid fuel, e.g. diesel engine fuel, because a sufficient amount of fuel can be stored to obtain the required autonomy need for the use in limited space without the weight of, for example, gaseous fuel tanks.

In principle, the turbine can be used to directly control (via a specific speed regulator) an air conditioning system compressor. Alternatively, the air  
15 conditioning system can be of the absorption type and be powered by the thermal energy of the turbine exhaust gas while the turbine provides mechanical energy to power the other utilities of the carriage after being transformed into electrical energy. However, since air conditioning systems on train carriages are powered - in normal conditions of use of the train - by  
20 electrical energy supplied by the railroad line, they are designed to use this source of power. In order to limit the interventions needed to adapt existing trains to fit the generating unit according to the invention, in the preferred embodiment of the invention, the emergency generating unit comprises an electrical generator operated by a turbine through a suitable speed reducer.  
25 An inverter receives the electrical energy from the generator and outputs electrical current with the characteristics needed to power the air conditioning system and the other utilities aboard the train. The characteristics of the inverter vary according to the type of electrical power normally found in railway track systems. This means that the emergency generating unit can be  
30 adapted to various railway systems which have different types of electrical power, e.g. direct current power or alternating current power, at various voltages.

Although it is possible to use one emergency generating unit for the entire train (if this is suitably short), considering the power involved according to size and weight of the turbine, it is however advantageous to equip each carriage in the train with a generating unit.

5       According to an advantageous embodiment of the invention, the generating unit comprises a supporting frame in which the turbine, the electrical generator and the inverter are arranged; the frame is provided with specific connection means to a carrying structure of the train carriage. The frame can be advantageously shaped and dimensioned to be housed in a  
10       compartment under the floor of the train. The turbine, the inverter, the electrical generator and the possible mechanical reducer between turbine and electrical generator are also dimensioned to be contained inside the frame.

Sliding guides, integral with the carrying structure of the train and cooperating with the frame supporting means, may be provided to facilitate  
15       insertion and extraction of the emergency generating unit in the compartment to make the unit easily inserted and removed.

The generating unit may present a circuit for regulating the rotation speed of the turbine and consequently - essentially - of the output power to ensure the output of a various power level according to the needs and to  
20       solve a number of problems (which will be illustrated below) related to the risk of fumes circulating inside the train.

Closing members are advantageously provided to close the turbine suction and exhaust manifolds while the train is running normally to prevent access of debris inside the turbine suction or exhaust manifolds.

25       The train may be equipped with a heating system in addition to an air conditioning system. Heating and air conditioning can possibly be obtained using a dual-acting or reversible machine, which is capable of cooling or heating according to requirements; the machine is powered by the emergency generator unit in the case of an emergency. Conversely, if heating and cooling  
30       is obtained by means of two separate systems (a cooling machine for air conditioning, for example, and electrical resistors for heating), the generating unit according to the invention may power alternatively either the cooling

machine or the heating resistors in the case of electrical power outage. Otherwise, heating may be obtained by a heat exchanger which directly employs the turbine exhaust gas and simultaneously generates mechanical energy which is transformed into electrical energy to power the other train utilities in the event of an emergency.

Additional characteristics and advantageous embodiments of the emergency generating unit and of the train using said emergency generating unit according to the invention are recited in the annexed claims.

#### Brief description of the drawings

The invention will be better understood following the description and the annexed drawings illustrating a possible advantageous embodiment of the invention wherein:

Fig.1 is a schematic cross-sectional view of a train;

Fig.2 is a block chart of the train;

Fig.3 is a transversal cross-sectional view according to III-III in Fig.1;

Fig.4 is a perspective view of the fuel tank;

Fig.5 is a lateral view according to V-V in Fig.3;

Fig.6 is an axonometric view of the emergency generating unit;

Fig.7 is a view according to VII-VII in Fig.6;

Fig.8 is a view according to VIII-VIII in Fig.7;

Fig.9 is a view according IX-IX in Fig.8; and

Fig.10 is a block chart of an emergency generator, an air conditioning system associated thereto and a control circuit.

#### Detailed description of the preferred embodiment of the invention

Figure 1 schematically shows the front section of a train, generically indicated by reference numeral 1. Reference numeral 3 indicates the locomotive and references 7A and 7B indicate the first two carriages or cars forming the train. Both traction and the various systems aboard the carriages - specifically the air conditioning systems - are powered by the line 9 through the pantograph 11 of the locomotive. In the event of breakdown concerning the pantograph, the power to the utilities and to the systems in carriages 7A, 7B, ... must be provided by emergency power units which equip each carriage

5, 7, .... Figure 2 schematically shows seven train carriages numbered from 7A to 7F. Each carriage is equipped with an emergency generating unit, schematically indicated by references 13A-13F. As indicated in detail below, each emergency generating unit 13 is housed in a compartment underneath  
5 the floor of the respective carriage. The compartment is equipped with a flap for lateral access, schematically indicated by reference numeral 15 in Figure 1.

Figure 3 shows a local transversal cross-sectional view according to line III-III in Figure 1. In Figure 3, reference numeral 17 indicates the floor of the carriage while reference numerals 19 and 20 indicate two adjacent  
10 compartments, underneath the floor 17 in the transversal direction of the carriage. Compartment 19 contains a frame 21 (see Figures from 6 to 9 in particular) which houses a turbine unit 23 (of which reference numeral 25 indicates the exhaust), a speed reducer 27, an electrical generator 29 and an  
15 inverter 31. The reducer 27 is arranged between the output shaft of the turbine 23 and the input of the electrical generator 29. It reduces the turbine revolutions to the values needed to operate the electrical generator 29. The electrical output of the generator 29 is transformed by the inverter so that it can power the equipment aboard the railway carriage 7. As shown in detail in  
20 Figures 3, 6 and 7, the exhaust manifold 25 of the turbine 23 presents an end or output mouth 25A which is in line with the bottom 19A of the compartment 19. This on one hand prevents projections of the exhaust manifold under the lower surface of the carriage which could cause hindrance or obstruction during normal train operation, and on the other prevents the hot fumes from  
25 the exhaust from burning material of the rail underneath. This is thanks to expansion and consequently cooling of the fumes in the diverging mouth of the exhaust manifold 25.

The conformation of the frame, the size and the arrangement of the units exploits the space in the compartment 19 optimally.

30 Within the compartment 19 two guides 33, which develop orthogonally with respect to the longitudinal direction of the carriage 7, are fastened to the structure forming the carriage. The frame 21 is inserted in the compartment by

means of the guides 33 and sections 35 integral with the frame by means of which the latter rests on the guides 33. A pivoting flap 37 hinged at 39 to carriage 7 is used to access the compartment 19.

A fuel tank 41 is housed in compartment 20, next to compartment 19;

5 the tank is provided with a filler 43 facing a pivoting flap to access compartment 21 indicated by reference numeral 45 and similar to flap 37. The tank 41 is fastened by means of integral brackets 47 to a beam forming part of the carriage structure. A compartment over the tank 41 houses the pump and the fuel filters. The contour of the tank 41 and the compartment 49 for the

10 pump and the filters is such to exploit the available space inside compartment 20 in an optimal fashion. The tank 41 can have a capacity, for example, of approximately 200 liters, which is sufficient to ensure an autonomy of approximately two hours to a turbine 23 which outputs 30-60 kW. Unlike the frame 21, which is extractable to permit maintenance operations and

15 interventions on the devices fitted on the frame, the tank 41 can be fixedly fitted inside the compartment 20, since it does not require interventions in normal conditions. The fuel filters in compartment 49 may be arranged in a position which is sufficiently accessible from the exterior by opening the flap 45; the entire unit 41, 49 will not need to be extracted from the compartment

20 20 in this way.

Figure 10 shows a block chart of the emergency generator unit, the cooling machine for air conditioning and the control circuit. The generator unit is generically indicated by reference numeral 13 and comprises: the turbine unit 23, with the compressor 24, the turbine itself 26 and the combustion

25 chamber 28; the reducer 27; the electrical generator 29; the inverter 31. A perforated plate 51 for measuring the rotation speed of the turbine is fitted on the shaft of the turbine 26. Sensing means 53 (e.g. of the magnetic, optical or other type) are associated to the plate 51 to detect the rotation speed of the plate 51 and consequently of the turbine 26. The signal is sent by the sensing

30 means 53 to a signal conditioning block 55. The signal output from the block 55 is frequency-modulated and frequency is proportional to the angular velocity of the turbine. A block 57, which receives the input signal from the

conditioning block 55, converts the frequency signal into a voltage signal. A reference voltage signal against which the signal from block 57 is compared is provided by a control unit 59, e.g. a microprocessor. The reference voltage from the control unit 59 is proportional to the required rotation velocity of the turbine and consequently to the power to be developed. The output signal from the adder 61 is sent to a compensation network 63 whose purpose is to avoid control loop oscillations. Suitably amplified by an amplifier 65, the output signal from the compensation network 63 controls a motor 67 for opening and closing a proportional valve 69 which feeds the fuel (from the tank 41) to the combustion chamber 28.

The output of inverter 31 has the same characteristics of the voltage needed to power the on-board systems. For example, in the case of ETR500 trains used by the Italian railways, direct voltage at 600 V. The electrical energy output by the inverter 31 can be used to power systems or utilities generically indicated by reference numeral 71 aboard the carriage where the specific emergency generating unit 13 is located. For example, it can be used for the lighting system, opening and closing the automatic doors between carriages, heating hot water for the on-board lavatories, etc. In winter the output can also be used for the heating system of the carriage. A considerable amount of the power output by the inverter 31 is used by a motor 73 which operates a compressor 75 of a cooling machine, generically indicated by reference numeral 77 of the on-board conditioning system. The following parts of this system are schematically indicated: a serpentine 79 for cooling the coolant compressed by the compressor 75, an expansion valve 81, a heat exchanger 83 for cooling the air from inside the carriage through a conduit 85. The flow of air cooled by the heat exchanger 83 is dehumidified and partially heated by the exchanger 79 to let suitably dehumidified air into the carriage through the conduit 87 at the required temperature. The air conditioning system 77 interfaces with the central control unit 59.

Other parts of the air conditioning system are not shown and are known per se. A line 60 carries a control signal to actuators from the control unit 59 to open and close air exchange apertures in the carriage. These

opening and closing systems are known per se and used when the train is running to close the apertures before entering tunnels to avoid abrupt changes of pressure. On the train according to the invention, these systems for opening and closing the air exchange flaps have a different and additional  
5 function which will be described below.

When the train stops due to failure of the overhead line 9 or to the pantograph 11, the emergency generating unit 13 is started by starting the turbine unit 23 (e.g. by means of an electrical motor powered by a small battery). All the emergency generating units 13 in all the carriages forming the  
10 train can be started in normal conditions, e.g. if the train stops outside a tunnel. To avoid the accidental access of combustion gas into the carriages 7, the apertures or flaps provided for exchanging the air can be closed by means of a signal by the control unit 59 on the line 60. Oxygen tanks may be provided and release a controlled amount of oxygen via valves operated by  
15 the control unit 59 into the carriages to ensure a sufficient amount of oxygen.

Alternatively, the unit 59 can lower the power output by the turbine unit 23 to reduce the rpm even until the first generator 13 is stopped. In such minimum power conditions or when the unit 13 is stopped, the vents for exchanging air inside the carriage can be opened. The ventilation system for  
20 exchanging air is kept running by the low power still output by the generator 13 (if this has not be switched off all together) or via a battery fitted on-board. Air is exchanged for a sufficiently long time after which the ventilation vents are closed and the first generating unit 13 is operated at full power again. In this way, air is exchanged when exhaust fumes of the generating unit 13 are  
25 minimal or entirely absent. This avoids that exhaust fumes from the turbine accidentally entering the carriage.

If the train stops in a tunnel and tunnel ventilation is not sufficient to eliminate all the fumes generated by the various turbines of the emergency generating units 13 of all the carriages, fume emissions can be reduced by  
30 operating for pre-determined time intervals a limited number of emergency generating units 13 in sequence, considering that particularly efficient cooling of the ambient inside the carriages is not required in tunnels. For example,



with reference to the numbering in Figure 2, a first group 13A, 13F can be operated for a first period of time; these units can be stopped once sufficient cooling is obtained in carriages 7A and 7F and units 13B and 13E can be switched on, and so forth in sequence. The sequence is then repeated for the  
5 time needed during which the train remains stationary. Conversely, a single generating unit 13 can be operated at a time, e.g. starting from the head of the train with generating unit 13A to the end of the train with generating unit 13F.

It is noted that the drawing shows only an embodiment of the invention  
10 which can change in form and arrangement without departing from the scope of the present invention. The presence of reference numerals in the annexed claims has the purpose of facilitating comprehension of the claims with reference to the description and does not limit the scope of protection represented by the claims.

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